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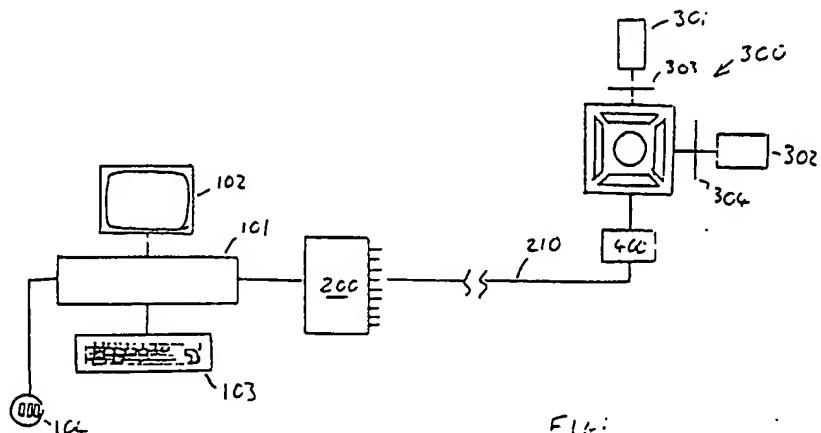
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## (54) Remote control system

(57) A control system for the remote control of equipment such as stage lighting or sound equipment 300 comprises a micro computer (101-104) which is used to input commands to the equipment. The setting of one item of equipment (eg, a spotlight) can be set by the user and then the setting(s) of other equipment can be calculated to achieve a user-set co-ordination between the operation of the items of equipment. Control signals are sent to the remote equipment in pulse width modulated form to achieve rapid updating with high noise immunity.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1982.

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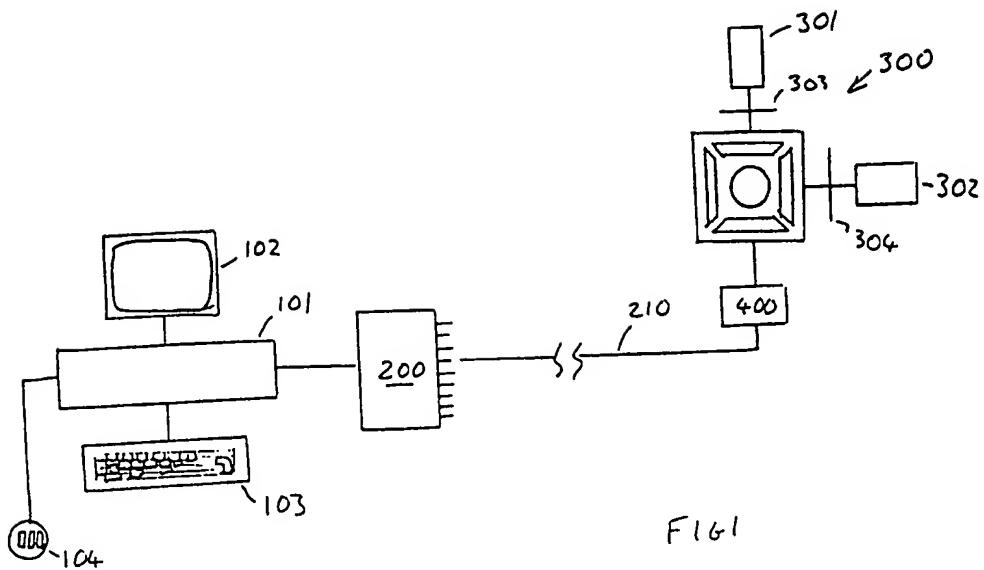


FIG 1

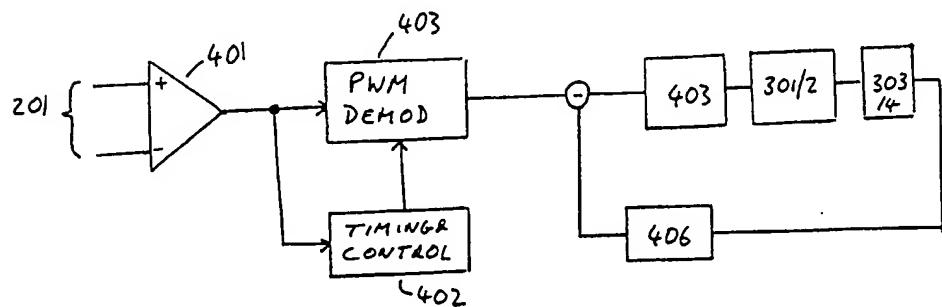
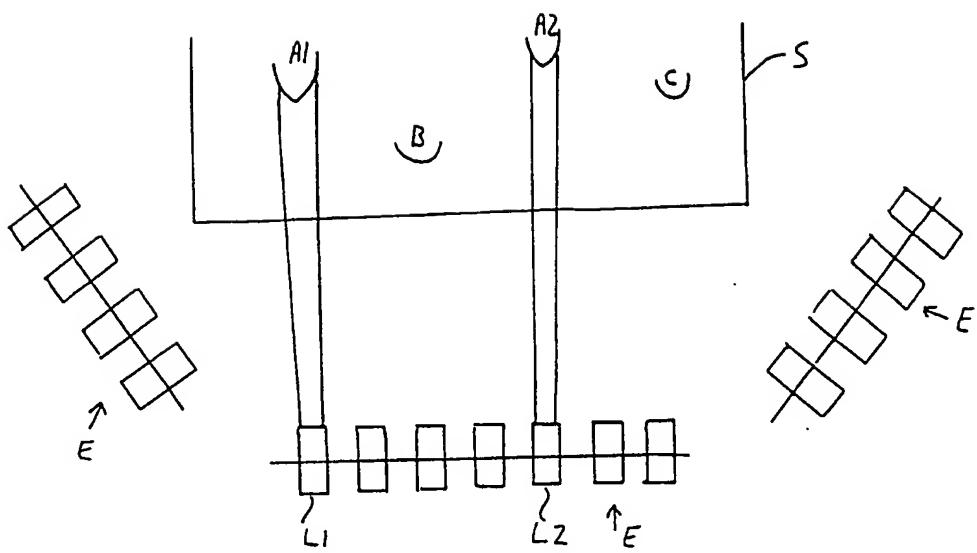


FIG 2

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FIG 3

REMOTE CONTROL SYSTEM

The present invention relates to a remote control system, particularly, but not exclusively, for use in controlling 5 lighting, sound and/or other stage equipment for stage performances and similar uses.

It is conventional to control stage lighting equipment from a control desk which is provided with a number of individual 10 controls for to what may be a large number of stage lights. Conventionally, such a desk is provided with facilities for fading in and fading out individual lights or groups of lights.

15 Over the past few years, stage lighting equipment has become available which has the facility for controlling remotely mechanical aspects of the operation of the individual lights. For example, each light may be provided with motor-driven mechanisms for controlling the pan and/or tilt of the light 20 and other operating parameters such as the iris aperture and focus of the light. Systems have been proposed in which the control desk

incorporates a desk-top computer into which commands for the individual lights can be typed by the operator. Perhaps 25 because of the basically digital nature of the controller and the trend towards the use of digital techniques generally,

such systems have transmitted the commands to the individual lights as digital data over a wire link, and individual lights have been provided with digital decoders which receive the commands from the control desk, decode and control the 5 electro-mechanical actuators associated with the light in accordance with the decoded commands.

Various problems have been encountered with such systems. The use of digital transmission requires a substantial degree of 10 local "intelligence" at the decoders associated with the individual lights, making the equipment expensive. Secondly, difficulties are encountered in operating such equipment because the operating environment is relatively hostile, both 15 electrically and physically, i.e; the power supplies to the lighting and sound equipment involves large electrical currents which are a source of noise and interference which can cause mis-operation of the digital equipment and, from a physical point of view, amongst other things, the equipment may generate a substantial amount of heat - present stage 20 lighting equipment may operate at power levels of several tens or even hundreds of kilowatts. Thirdly, neither the use of a conventional control desk layout of faders nor input of commands from computer keyboards provides a simple and rapid 25 method of setting up and issuing commands for operating the lights in a coordinated fashion.

The present invention is concerned, inter alia, with reducing the above problems. It is not limited, however, to applications where those specific problems arise.

- 5 A first aspect of the present invention provides a control system for controlling operation of a number of remote electrical devices, comprising a user-operable system controller for enabling a user to set operating variables of the remote devices, and generating corresponding control signals for each of the controlled devices, means for transmitting the control signals to the remote devices, and means associated with each of the remote devices for decoding the control signals received from the system controller and setting the operating variable (s) of the associated device as commanded by the control signals, the system controller being operative to accept user-input setting the required value of the operating variable of one of the remote devices and a user-command which instructs the corresponding operating variable of at least one other remote device to be set to a value coordinated with that value, to calculate the required coordinated value of the operating variable of that other remote device or devices and to generate the corresponding command for that other remote device or devices.
- 10
- 15
- 20
- 25 In the application of this aspect of the invention to the control of the pan and/or tilt of two or more stage lights,

suppose that the operator requires two spotlights to converge on the same point on the stage or to follow the same path at the same time on the stage. In those circumstances, the system controller is arranged to accept commands from the user

5 setting the position (or sequence of positions) required of one of the spotlights, to calculate and generate the corresponding command signals for that spotlight and transmit them to the spotlight which has control circuitry associated with it which de-codes the commands and operates the spotlight

10 accordingly. The system controller further accepts a command from the user as to the manner in which the operation of the second spotlight is to be coordinated with that of the first (as by being directed at the same spot or following the same path), calculates the required value or sequence of values of

15 the operating variable (eg; pan and/or tilt) of the second spotlight required to achieve the instructed coordination and then generates and transmits those commands to the second spotlight, simultaneously with the first spotlight, or not depending on the coordination required. Facilities in the

20 controller may be provided for enabling the user to see the effect of a "test run" of the command or commands to the first spotlight before the system controller generates the coordinated commands for the second one.

25 A second aspect of the present invention provides a control system for controlling the operation of one or more remotely

located lighting, sound or other stage equipment comprising a user/operable system controller for user/setting operating variables of the remote equipment and for generating corresponding command signals to the control equipment, means 5 for transmitting the control signals to the remote equipment, and means associated with the remote equipment for decoding the command signals received from the system controller and setting the operating variable (s) of the associated device accordingly, the required value of the operating variable 10 being encoded for transmission as the pulse-width modulation of pulses in a train of pulses transmitted to the remote device.

For the or each remote item of equipment, a number of 15 operating variables (eg; in the stage lighting application, the pan and/or tilt of a stage light), they be controlled by the system controller. In those circumstances, the command signals for each variable may be time-interleaved in a cyclical fashion, so that the pulse train transmitted 20 comprises a cyclical succession of pulse-width modulated pulses representing commands for respective operating variables of the particular remote device. It has been found that such an arrangement provides a good degree of immunity from noise and other interference in the hostile stage 25 environment, enables the individual remote devices to be controlled by circuitry which does not have to possess a

substantial degree of local intelligence and enables the commands for each device to be updated very frequently without requiring a very high data transmission rate.

5 A control system incorporating both of the above aspects of the present invention will now be described by way of non-limitative examples reference to the accompanying drawings in which:-

10 Figure 1 is a schematic block diagram of a control system in accordance with both aspects of the present invention;

Figure 2 is a schematic block diagram of the de-coder associated with one of the remotely controlled devices in the  
15 system of figure 1;

Figure 3 is a schematic plan view of a stage showing how the system may be used to coordinate the operation of two or more stage lights to achieve a required effect.

20 Before describing in detail the illustrated embodiment of the invention, reference will be made to Figure 3 which illustrates one typical way in which it may be used.

25 In Figure 3, S denotes a stage on which a performance is to take place, lit by stage lighting equipment E which includes,

amongst others, spotlights L1, L2 which are currently directed at areas A1 and A2 of the stage. The lighting equipment operates under the control of a lighting (and optionally, sound) control desk D. The spotlights L1, L2, are of a type 5 having electromechanical actuators to set their pan and tilt angles.

Suppose that the operator wishes the spotlights L1, L2 to pan and tilt in synchronism so that they end up converging at 10 point B. The illustrated embodiment is provided with control facilities whereby a computer (100 in Figure 1) at the desk D has data as to the current and required positions of the spotlights L1, L2 and can calculate and transmit to each of the two spotlights a sequence of position commands which will 15 result in their beams converging at the required position B at the same time. Even where the positions of the two spotlights relative to the stage are not symmetrical, given data as to their actual positions, the computer can calculate the required sequences of movements of the two spotlights to 20 coordinate their actions as required.

As a second example, the operator might want both of the spotlights to move in synchronism from position B to a position C and again it can calculate the required sequences 25 of position commands for the two lights so that they move in the required way, even allowing for assymetries in their

positions.

Where coordination of the operation (e.g. the movements) of two or more such lights is required, the present invention 5 proposes a method of operation which does not require the operator to programme each of the lights individually. Specifically, it is proposed that the software of the computer of the desk D is arranged so that it first accepts a command (or series of commands) from the user indicating the action(s) 10 required of one of the devices to be controlled - in this case the lights (say, L1 in Figure 3) and then a command in respect of one or more of the other devices indicating the coordinated action required (e.g. in the case of light L2, arrive at C at the same time or move in a manner to keep its beam parallel, 15 say, to that of L1). Any number of other required coordinated actions of the controlled devices may be handled in a similar way.

Referring now to Figure 1, this shows the overall arrangement 20 of the illustrated embodiment. The control desk D of Figure 3 is provided with a desk-top computer 100 (e.g. an IBM PS2 System 50 PC) which comprises a system unit 101, VDU 102, keyboard 103 and two-axis input device 104 such as a "mouse", trackball or lightpen. The computer 100 operates under the 25 control of a suitably written application program running under a convenient operating system such as MS Windows. The

VDU 102 can display a map in plan or perspective of the stage and the lighting and other equipment which is to be controlled and the input device 104 can be used to select lights and other items of equipment whose operation is to be controlled  
5 and to call up "icons" or menu-bars to pre-programme or operate in real time the items in question. The device 104 and/or the keyboard 103 can further be used to control the operating mode of the software, establish the required settings or operation of the items of equipment to be  
10 controlled and so forth.

The computer 100 calculates the required commands for each of the lights, etc., which are to be controlled and outputs them via a standard high-speed parallel communications port to a  
15 transmitter 200 which distributes the commands across a number of output channels for transmission via cables such as 210 to the individual items (or groups of items, where appropriate). One such item, a pan and tilt spotlight is shown at 300. For functions which do not register a change between successive  
20 cycles (i.e. the instructed value does not change), the previous value is retransmitted.

The transmitter 200 acts in effect as a time-division demultiplexer, distributing the serially generated command  
25 signals across its N output channels. N may be, say, 40, with, say, 9 functions (per light or other controlled device) on

each channel. The pulse rate on each channel may be such that, say, 40 or 50 cycles of the various function signals on each channel occur per second. The transmitter 200 also serves to produce the appropriate pulse width modulated signals for transmission and incorporates suitable line drivers for driving the cables 210. These may be screened twisted wire pairs to which a balanced drive signal is applied so as to reduce the sensitivity to electrical noise.

10 The spotlight 300 has electronically controlled pan and tilt DC electric motors 301, 302 which are actuated by circuitry 400 as required in accordance with the PWM signals received via the associated cable 210. The control signal comprises a cyclically repeating series of PWM pulses; each of the pulses 15 in the series may represent the required setting of a different operating parameter of the device (in this case, the spotlight) under control. In the case of a spotlight, the parameters can include: pan & tilt angles, iris setting, which one of a number of colour filters is to be in effect, lamp power and so forth (alternatively the lamp power may be controlled by conventional triac or SCR phase control of the mains supply to the lamp). The width modulation (and subsequent demodulation and position servo) is preferably such 20 as to allow an overall resolution of 11 bits or more in 25 positional commands, although in certain applications lower resolutions may be acceptable.

Figure 2 illustrates part of the control circuitry 400 associated with the light 300. A differential amplifier 401 whose inputs are connected to the two wires of the twisted 5 pair signal cable 210 produces an output voltage whose waveform is the PWM pulse signal containing the commands for the light 300. This signal is applied to a timing signal generating circuit 402 which generates a clock signal used to identify each of the PWM pulses in the repeating series and to 10 route them to corresponding decoding circuits. One such circuit is shown at 403 and is operative to convert one of the pulses in the series (say, the commanded tilt angle) to a DC voltage corresponding to the commanded value which is sampled and held to produce a DC level  $V_c$  which indicates the 15 commanded value. This decoding may take place in any suitable fashion. For example, an analogue or quasi-analogue ramp may be started as the PWM signal crosses zero (or reaches some other preset value) going in one direction and by sampling and holding the value of the ramp when the PWM pulse crosses zero 20 going in the other direction, a DC voltage corresponding to the demanded value can be derived. Alternatively, a digital code can be derived directly from the width-modulated pulse and converted to analogue by a D/A converter.

25 The voltage  $V_c$  is applied as a set point signal to the set point input of a servo circuit 404 which in the cases of the

pan and tilt angles operates as a position servo. A drive amplifier 405 applies to the pan or tilt motor 301/302 a DC drive voltage proportional to the difference between the set-point signal  $V_c$  and an error voltage signal  $V_e$  derived by 5 analogue-to-digital converting in D-to-A circuit 406 the output of a sensor reading an optical position encoder disk 303/304 (or other position detector such as a potentiometer) on the output shaft of the motor 301/302. The motor is thus operated to servo the pan or tilt angle, as appropriate, to 10 the position commanded by the incoming PWM pulse from the computer 100.

The demultiplexing of the pulses in the incoming train may take place before or after each of the PWM pulses is converted 15 to a DC voltage. Demultiplexing after conversion has the advantage of only requiring one PWM decoder; the succession of sampled and held levels can then be distributed across the various output channels by demultiplexing them via analogue switches operated by the timing circuit 402 to individual 20 sample and hold circuits associated with each of the output channels.

Circuits such as 404 may be provided for each of the controllable analogue functions of the light 300 which it 25 desired to control. Further, the light 300 may have one or more "digital" functions which only assume one of a finite

- number of states (e.g. the opening or closing of shutters) or the position of a colour filter wheel, and PWM command pulses to control these states may be incorporated in the PWM pulse train. Other functions may be controlled in the same way; for 5 example it may be desirable to have "calibration" commands which cause the light's various functions to be reset to a predetermined initial state (e.g. the pan and tilt angles are set to values at one or other end of the operating range.
- 10 The use of the PWM pulse train provides good noise immunity, avoids the need for local "intelligence" in the circuitry at each of the devices being controlled and complex two-way digital signalling protocols, and, perhaps most importantly, enables the commanded values of each of the controlled 15 parameters of an individual light to be updated at a high rate.

- The system above described, as well as overcoming the problem described above of existing systems has a number of 20 advantages, including:-
- 1) The use of PWM enables a speed of response which can provide "instant" effects.
  - 2) By avoiding have local intelligence at the controlled devices it avoids the need for error checking which slows the 25 speed of transmission.
  - 3) The speed of initialising the system is greatly reduced

-existing systems may take several minutes.

4) Interfacing with other apparatus is easy and they can be controlled in the same way by the software, using icons to represent them.

5 5) The reliability and flexibility of the system is increased, while the cost is decreased.

6) The intelligence of the system is provided by an industry-standard, widely available and supported computer.

7) Language problems on the part of the operator are 10 largely avoided by the use of a graphical representation of the controlled environment and by the other facilities available in a computer windowing environment.

8) Interfacing with existing "off the shelf" controllers such as MIDI interfaces is easily carried out.

15

Although, in the above, the invention has been described with reference to the control of stage lighting it may, of course, be applied to a wide range of stage and other equipment, including cameras and stage effects equipment and sound

20 equipment.

CLAIMS

1. A control system for controlling operation of a number of remote electrical devices, comprising a user-operable system controller for enabling a user to set operating variables of the remote devices, and generating corresponding control signals for each of the controlled devices, means for transmitting the control signals to the remote devices, and means associated with each of the remote devices for decoding the control signals received from the system controller and setting at least one operating variable of the associated device as commanded by the control signals, the system controller being operative to accept user-input setting the required value of the operating variable of one of the remote devices and a user-command which instructs the corresponding operating variable of at least one other remote device to be set to a value coordinated with that value, to calculate the required coordinated value of the operating variable of that other remote device or devices and to generate the corresponding command for that other remote device or devices.

2. A control system according to claim 1, wherein the system controller is operative to accept a user command designating the manner in which the operation of the at 5 least one other device is to be co-ordinated with that of the one remote device.

3. A system according to claim 1 or 2 in which the remote devices comprise stage lighting or stage effects equipment, 10 sound equipment and/or cameras.

4. A system according to claim 3 wherein the remote devices include devices for the control of the pan and/or tilt of two or more stage lights.

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5. A system according to claim 4 wherein the stage lights include spot lights the system controller is arranged to accept commands from the user setting the position, or sequence of positions, required of one of the spotlights, to 20 calculate and generate the corresponding command signals for that spotlight and transmit them to the spotlight, the

spotlight having control circuitry associated with it which decodes the commands and operates the spotlight accordingly.

5 6. A system according to claim 5 wherein the system controller is arranged to accept a command from the user as to the manner in which the operation of the second spotlight is to be co-ordinated with that of the first to direct the second spotlight at the same spot as the first spotlight or 10 following the same path, to calculate the required value or sequence of pan and/or tilt of the second spotlight required to achieve the instructed co-ordination and to then generate and to transmit those commands to the second spotlight.

15 7. A control system for controlling the operation of one or more remotely located lighting, sound or other stage equipment comprising a user/operable system controller for user/setting operating variables of the remote equipment and for generating corresponding command signals to the control 20 equipment, means for transmitting the control signals to the remote equipment, and means associated with the remote

- equipment for decoding the command signals received from the system controller and setting at least one operating variable of the associated device accordingly, the required value of the operating variable being encoded for transmission as the pulse-width modulation of pulses in a train of pulses transmitted to the remote equipment.
8. A system according to claim 7 wherein there are a number of operating variables associated with a remote equipment and the system controller is operative to time-interleave the command signals for each variable for that remote equipment may be time-interleaved in a cyclical fashion, so that the pulse train transmitted comprises a cyclical succession of pulse-width modulated pulses representing commands for respective operating variables of that particular remote equipment.
9. A control system according to claim 7 or 8 wherein the system controller is arranged to enable a user to set operating variables of the remote equipment, and generating corresponding control signals for each of the controlled

equipment, means for transmitting the control signals to the remote equipment, and means associated with each of the remote equipment for decoding the control signals received from the system controller and setting at least one 5 operating variable of the associated equipment as commanded by the control signals, the system controller being operative to accept user-input setting the required value of the operating variable of one of the remote equipment and a user-command which instructs the corresponding operating 10 variable of at least one other remote equipment to be set to a value co-ordinated with that value, to calculate the required co-ordinated value of the operating variable of that other remote equipment and to generate the corresponding command for that other remote equipment.

15

10. A control system according to claim 1, wherein the system controller is operative to accept a user command designating the manner in which the operation of the at least one other equipment is to be co-ordinated with that of 20 the one remote equipment.

11. A system according to claim 1 or 2 in which the remote equipment comprise stage lighting or stage effects equipment, sound equipment and/or cameras.

5 12. A system according to claim 3 wherein the remote equipment includes equipment for the control of the pan and/or tilt of two or more stage lights.

13. A system according to claim 4 wherein the stage lights 10 include spot lights the system controller is arranged to accept commands from the user setting the position, or sequence of positions, required of one of the spotlights, to calculate and generate the corresponding command signals for that spotlight and transmit them to the spotlight, the 15 spotlight having control circuitry associated with it which decodes the commands and operates the spotlight accordingly.

14. A system according to claim 5 wherein the system 20 controller is arranged to accept a command from the user as to the manner in which the operation of the second spotlight

is to be co-ordinated with that of the first to direct the second spotlight at the same spot as the first spotlight or following the same path, to calculate the required value or sequence of pan and/or tilt of the second spotlight required 5 to achieve the instructed co-ordination and to then generate and to transmit those commands to the second spotlight.

15. A control system according to any one of claim 2 to 6  
10 or any one of claims 10 to 15 wherein the system controller has associated with it a display for displaying a visual representation of a stage area and equipment or devices to be controlled.

15 16. A control system constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.